Podium Presentations

Session VIII: Vibration Reduction and Machine Testing

Chairs: Jack Wasserman and Alan Mayton

SEAT CUSHION AND POSTURE EFFECTS IN MILITARY PROPELLER AIRCRAFT VIBRATION ENVIRONMENTS

Suzanne D. Smith[1], and Jeanne A. Smith[2]
[1]Air Force Research Laboratory, [2]General Dynamics AIS
Wright-Patterson AFB, Ohio, U.S.A.

Introduction

Annoyance, fatigue, and musculoskeletal pain have been reported during prolonged exposures to propulsion-generated vibration in military propeller aircraft[1]. The objective of this study was to determine the vibration mitigation properties of selected seat cushions and the effects of occupant seating posture during exposure to higher frequency multi-axis vibration associated with military propeller aircraft.

Methods

A Navy E-2C Hawkeye crew seat was mounted onto the Six Degree-of-Freedom Motion Simulator (SIXMODE). Six seat pan cushion configurations were tested during exposure to an E-2C vibration signal collected in the field[1]. Seat pan cushions 1 – 5 were used with the original E-2C seat back cushion. Cushion configuration 6 included seat pan cushion 5 with a prototype seat back cushion. Triaxial accelerometer pads were mounted onto the seat pan and seat back cushions to measure the vibration entering the human. Data were collected for seven subjects seated upright with their backs in contact with the seat (back-on) and not in contact with the seat (back-off). Spectral analysis techniques were used to analyze data at the two dominant frequencies associated with the propulsion system (propeller rotation frequency (PRF) ~18.5 Hz, and blade passage frequency (BPF) ~73.5 Hz). Overall accelerations were also calculated between 1 and 80 Hz. Vibration Total Values (VTVs) were calculated using the weighted seat pan and seat back (back-on only) accelerations and compared to the comfort reactions given in ISO 2631-1: 1997[2].

Results

In general, the highest accelerations observed at the seat pan occurred in the fore-and-aft (X) direction at both the PRF and the BPF for all cushions and both postures. The most pronounced effect was at the BPF in the X direction, where all configurations showed significantly lower seat pan accelerations than configuration 1 (original E-2C cushion) with the back-on posture. Configuration 5 was the exception with the back-off posture (Fig. 1A, Repeated Measures ANOVA, $P<0.05$). The most pronounced effect of posture occurred at the PRF in the X direction, where all cushion configurations showed significantly lower seat pan accelerations with the back-off posture (Fig. 1B).

All configurations except configuration 2 showed similar VTVs as compared to Configuration 1 (Fig. 2, $P<0.05$). Configuration 2 tended to show the lowest weighted acceleration levels. The overall VTVs (back-on only, Fig. 2B) showed significantly higher accelerations as compared to both the back-on and back-off seat pan point VTVs (Figs. 2A &

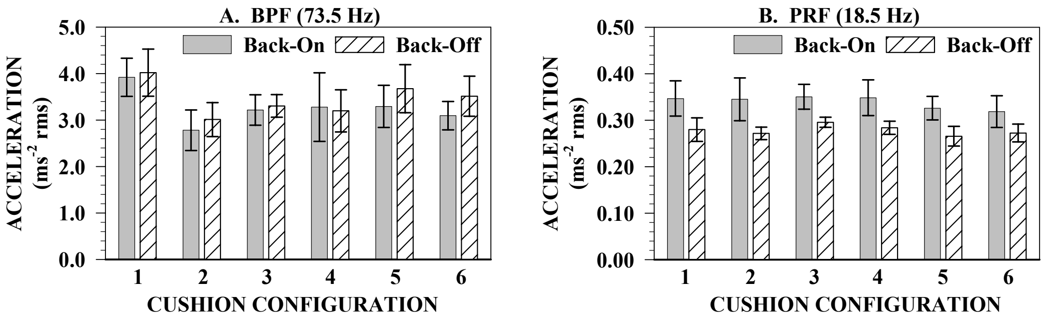

Figure 1 Mean Seat Pan X Accelerations +/- One Standard Deviation at the A. BPF and B. PRF

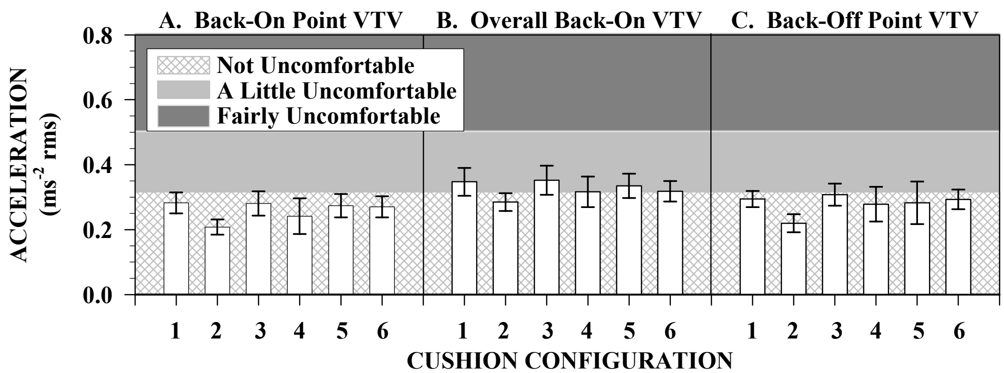

Figure 2 Mean VTVs +/- One Standard Deviation

2C) (Paired t-test, $P<0.05$). Configurations 3, 4, & 6 showed significantly higher back-off point VTVs (Fig. 2C) as compared to the back-on point VTVs (Fig. 2A). Figures 2B & 2C suggest that, in several instances, vibration would be considered at least "a little uncomfortable."

Discussion

The psychophysical effects reflected in the VTVs indicated that the occupants may only perceive a reduction in the vibration with Configuration 2, regardless of the unweighted results. It is noted that the ISO comfort reactions are based on public transport and may not reflect aircrew comfort perception during prolonged exposures. Posture, relative to sitting in contact with the seat back (back-on), does appear to have a significant effect on the vibration. Although not shown, the highest unweighted seat back vibration occurred in the vertical direction, while the highest weighted seat back vibration was estimated to be in the X direction (back-on). These results render it difficult to determine an appropriate strategy for reducing discomfort by mitigating higher frequency vibration through seat cushion design alone. Newer seat designs (active or semi-active vibration isolation systems) may improve seating comfort during prolonged vibration exposures.

References

1. Smith, S.D. (2006). Seat vibration in military propeller aircraft: characterization, exposure assessment, and mitigation. Aviation, Space, and Environ. Med. 77, 32-40.
2. International Organization for Standardization (1997). Mechanical vibration and shock – evaluation of human exposure to whole-body vibration – part 1: general requirements. ISO 2631-1: 1997.